Chapter 4. Fish

4.1. Changes in the fish community of Plum Island Sound from 1965 through 1994.

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4.11. Introduction

Fish are one of the most obvious and ecologically important groups of organisms within the Sound and their population characteristics have been linked to the health of estuarine ecosystems (Deegan et al., 1993). They may also be indicative of trends in the Massachusetts Bays region, since many fish that inhabit Plum Island Sound are migratory and therefore make regular movements between the Sound, the Bay and depending on the species, even further beyond.

The 1968 DMF estuarine monograph on the Parker River and Plum Island Sound gave an excellent and thorough review of the history of the fisheries in the Plum Island Sound region since colonial times (Jerome et al., 1968). DMF also carried out an extensive one year program of field sampling to characterize the fish community of the region. A major initiative of the Plum Island Sound Minibay and the Woods Hole LMER (Land Margin Ecosystems Research, precursors to the current LTER) projects was to assess changes in the fish community of the Sound since the Jerome et al. study. This was accomplished by carrying out a program of fish sampling in 1993/4 similar to what Jerome et al. had done in 1965 and published in 1968.

4.12. Methods

Jerome et al. (1968) collected fish within the Sound at six beach seining stations and 11 trawl stations at monthly intervals over a period of one year in 1965. At each station, DMF biologists identified fish to species and counted the number of individuals of each species. Over a 16 month period in 1993-1994 researchers from Massachusetts Audubon Society and the Woods Hole Ecosystems Center (MAS/WH) sampled for estuarine fish using beach seines and trawls at the same stations as Jerome et al. The methods were almost identical as well. Sampling was carried out once a month from June 1993 through October 1994 except in January and February 1994 because of ice conditions on the Sound and in September 1994. Locations of the sampling stations are indicated in Figs. 4.1a-b.

4.121. Beach seining

Six shoreline stations (stations 1-6) were sampled with beach seines in both 1965 and 1993/4. The stations are described in Table 4.1.

At each shore station for the Jerome et al. survey, two 15.2 m hauls were made with a 6.1 x 2.4 m minnow seine that had a mesh size of 4.8 mm (3/16 inch). This was done for a qualitative assessment of the fish and invertebrates present (W. Jerome, pers. comm. April 1996). The data from the 6.1 x 2.4 m seine hauls were not included in the tables presented in the 1968 monograph. For quantitative work, two sets were made with a 15.2 x 1.2 m haul seine which had a mesh size of 3.2 mm (1/8 inch). The net contained a bag in the middle also with a 3.2 mm mesh. All quantitative results reported in Jerome et al. (1968) were based on these seine hauls.

The following description of the exact seining procedure was based on conversations with W. Jerome (pers. comm. April 1996). Each end of the net was attached to 15.2 m ropes. One person standing on shore held the unattached end of the rope while a small boat containing the seine moved perpendicular to the shoreline until the 15.2 m rope was played out. The boat then turned and released the net into the water parallel to the shoreline. When the net was completely played out, the boat returned perpendicular to the shoreline. The net was then hauled in using the 15.2 m ropes and eventually the ends of the seine itself. Thus the seine haul described a rectangle with 15.2 x 15.2 meter sides or 231 m^2. Fish were identified and counted in the field.

The seines used by MAS/WH were 15.2 m length and either 1.2 or 1.8 m in height with a 4.8 mm (3/16 inch) square ace mesh. The middle of the seines were fitted with a bag (1.8 x 1.8 m) of the same mesh size as the wings of the net. A lead line insured that the bottom of the net remained in contact with the substrate. Once a locus was selected, one person held one end of the net and stood at a fixed position at the edge of the water. A second person took the other end of the net and walked out in the water perpendicular to the shoreline at the point where the first person was standing. When the net was straight, it would be checked along its length to insure that it was deployed correctly. The person at the deep water end would then move toward shore describing an arc while the person at the water's edge remained fixed. Thus each seine tow covered a quarter of a circle with a radius of 15.2 m and an area of about 180 m^2.

When the far end of the net was almost at the shoreline, the two people holding the ends of the net would walk toward each other and then move slowly up the beach until the net was completely out of the water. Fish and selected macroinvertebrates (decapod crustaceans) were then placed in plastic bags and stored in a cooler for later identification and enumeration back at the laboratory. Triplicate seine hauls were taken at all stations, with care taken in the second and third haul to avoid areas that had been impacted by the previous haul.

A seine team typically consisted of three or more people. In addition to the two people holding the ends of the seine, a third person checked along its length while it was being deployed to insure that it was sampling properly, i.e. lead line down, no tangles, etc. Additional people, often volunteers, helped with collecting the samples from the net after it was hauled ashore.

At each seine station, temperature and salinity (by refractometer) were measured, and the depth at the deep end of the net was estimated. Almost all depths were between 0.4 and 1.0 meters.

Table 4.1. Shoreline stations sampled by beach seine. Stations 1-6 were selected to be as close as possible to shoreline stations sampled by DMF in 1966.

Station 1. Great Neck, Ipswich near Pavilion Beach, a narrow strip of land that separates Great Neck from Little Neck on the western shore of Plum Island Sound. MAS/WH located their station 1 several hundred meters north of DMF's 1965 Little Neck station because they found the DMF station too cobbly at this point to reliably seine. MAS/WH Station 1 was located on a flat, very gently sloping sandy beach just north of an area of small rocks interspersed with salt marsh vegetation that separates the site from the northern end of Pavilion Beach. Sampling was always carried out within two hours of low tide.

Station 2. Bluffs, Ipswich. This station was located on the eastern side of Plum Island Sound several hundred meters south of the private residence on Stage Island. It was in a relatively sandy area at the seaward edge of a tidal flat that extends out from Stage Island. It was sampled at low tide. The gradient was gentle.

Station 3. Knobs. This station was a small gently sloping sandy beach bordered by salt marsh on three sides. The station is at the end of the dirt road that extends west past the southern border of the Bill Forward pool on the Parker River National Wildlife Refuge (PRNWR). It was seined at mid to low tides. New salt marsh vegetation covered the upper edge of the beach, thus unlike DMF who reported that the beach was devoid of vegetation, this area could no longer be seined at higher tides in 1993/4.

Station 4. Nelson's Island. This station, also on the PRNWR, was located at the edge of a tidal flat at the end of the dirt road that runs from the refuge parking lot at the end of Stackyard Road across the salt marsh to Nelson's Island. The substrate was a muddy sand with occasional disturbance by commercial clammers. Since the upper edge of the station was bordered by a steeply-banked salt marsh, it was seined at mid to low tides (2-3 hours on either side of a low tide) when the marsh was not flooded. Extreme low water was avoided because the flat sloped steeply into a channel that was too deep to allow to extension of the net to its proper length.

Station 5. Subheadquarters. This station was located on the extensive mud flat just west of the maintenance buildings of the PRNWR. In sampling this station we were faced with the greatest time constraint since it was too dry during much of low tide, but could also not be seined from mid to high tide because of the steeply banked salt marsh at the upper edge of the mud flats. There was generally a 45 minute "window" between two to three hours before or after dead low where this station could be seined. This mud flat was frequented by commercial clammers.

Station 6. Newbury Town Landing. This station was located on mud flats on the north shore of the Parker River several hundred meters downstream from the Newbury's old town landing at the end of Cottage Street. The DMF sampling station was at the landing itself. MAS/WH moved downstream slightly to be out of the influence of the mooring and launching area for boats. The mud flats bordered a steep salt marsh bank on the PRNWR. The soft sediments were interspersed with occasionally "clumps" of salt marsh peat that had probably slumped from the edge of the bank, thus care had to be taken to find a flat area for seining. Sampling was done within three hours of maximum low water. This station had strong tidal currents, particularly as the tide approached mid tide.

Fig. 4.1a. DMF Fish Sampling Stations

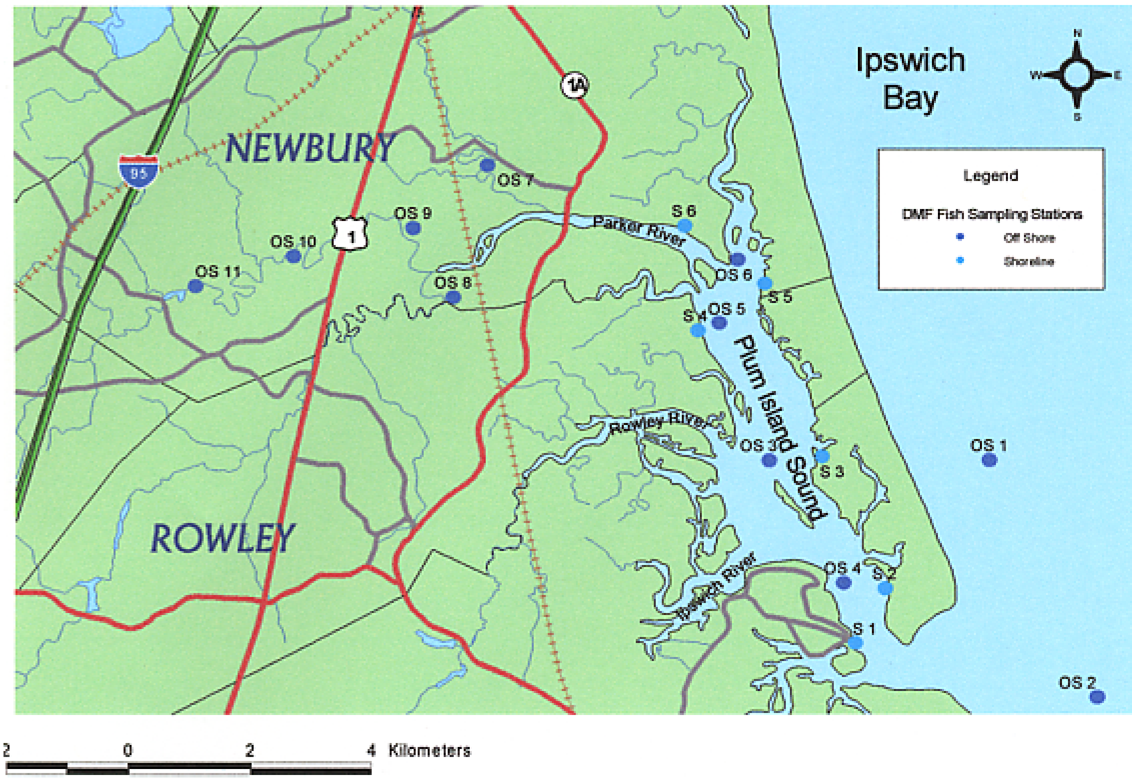
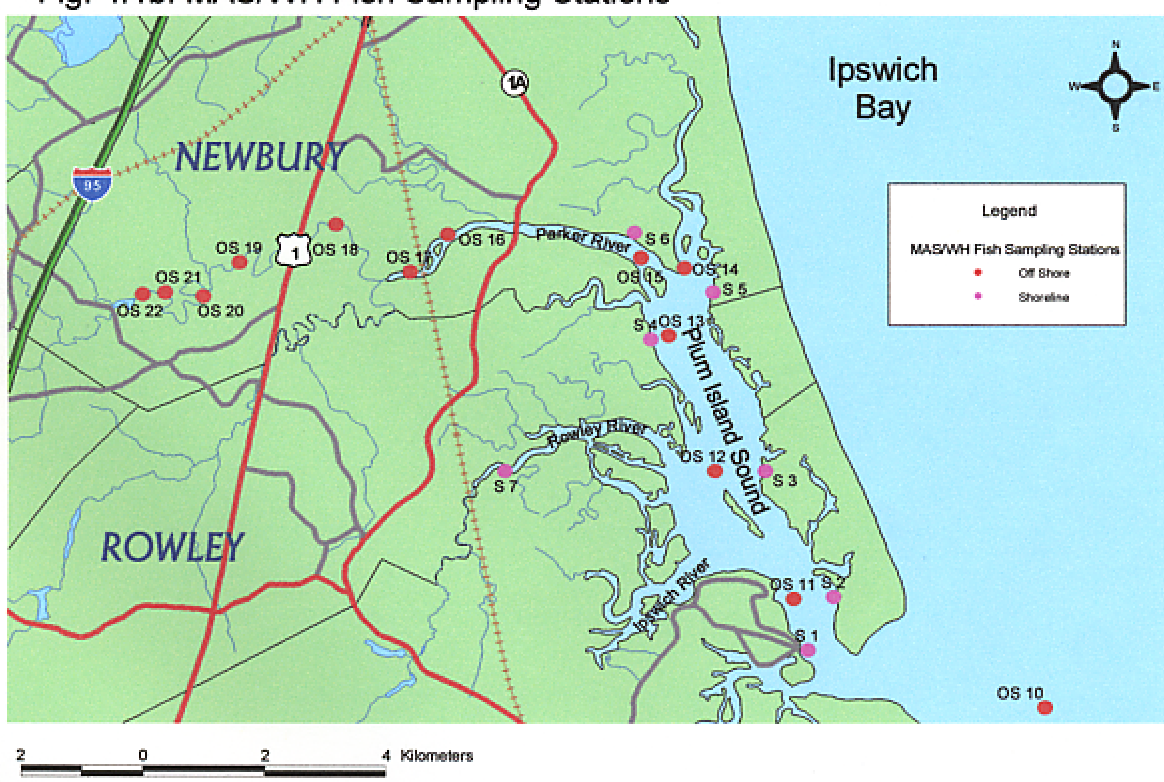


Fig. 4.1b. MAS/WH Fish Sampling Stations



4.122. Trawling

DMF used the 40-foot commercial dragger *Peggybell* to sample two offshore stations near the mouth of the Sound and one in Ipswich Bay. One twenty minute tow was made at each station with a trawl having a sweep of 14.8 meters and a headrope of 11.5 m. The stretched-mesh size of the twine in the wings and cod end was 12.7 cm and 10.2 cm, respectively. Finfish were examined to determine species composition, relative abundance and size distribution.

DMF used a shrimp trawl, with a sweep of 9.1 m and a headrope of 7.6 m at eight additional stations in the northern part of the Sound and in the Parker River to provide supplementary finfish data. The stretched-mesh size of the twine in the wings and the cod end was 3.8 cm and 2.5 cm, respectively. A five-minute tow was made at each station with the aid of a 16-foot outboard powered work boat.

For the 1993/4 study, trawling was carried out with a 4.9 m otter trawl (mesh size of 1.91 cm in the wings and 0.48 cm in the cod end) towed behind a 16 foot Boston Whaler. Trawls in Plum Island Sound (stations 10-15) were generally carried out for 2 minutes at speeds of about 1.5 m s^{-1}. Trawls in the Parker River (stations 16-21) were carried out for only one minute, due to obstructions within the river that precluded longer trawls. Shorter tows were noted on the data sheets and factored into our calculations. Each station was trawled in triplicate at each sample date, however the narrow confines of some Parker River stations (see below) often forced us to trawl over the same area.

The location of trawl stations in Plum Island Sound in the 1993/4 study was based largely on those sampled by Jerome et al. (Table 4.2) with a few modifications. MAS/WH did not sample DMF's offshore station OS1 (Camp Sea Haven) in Ipswich Bay, because they were limited by a smaller boat. The MAS/WH survey also did not include the station off Great Neck (DMF's OS4) because the area now contains a large number of moorings. MAS/WH did add a station at the entrance to the Parker River.

Trawling in the Parker River itself presented a challenge because of the large number of underwater obstacles and meanders. Rather than attempting to resample the same stations as in the DMF study, MAS/WH selected six stations that ran the length of the tidal part of the river that we felt could be reliably trawled for at least one minute (Table 4.2).

Table 4.2. Trawl Stations. Stations in Plum Island Sound were selected by MAS/WH to be as close as possible to the DMF offshore stations except where noted. In the Parker River upstream from Route 1A, there was no attempt to overlap exactly with DMF sites because of the existence of obstacles, such as underwater snags, that limited what could be trawled now. Nonetheless, the six Parker River stations of MAS/WH should represent similar habitats to what DMF sampled there.

Plum Island Sound Stations:

Station OS1. Camp Sea Haven. This station was located southeast of Camp Sea Haven in Ipswich where the water depths averaged 9 meters at mean low water. It was sampled by DMF, but not MAS/WH.

Station 10. Castle Neck. This station was at the mouth of Plum Island Sound and could be sampled at all tides. It was similar to DMF's OS2, however MAS/WH trawled in shallower water. The substrate was sand. Depth was about 1.5 m at low water.

Station 12. Middle Ground. This station was located just north of the Middle Ground, a salt marsh island in the southern section of Plum Island Sound. Equivalent to DMF's OS3. The substrate was sand. Depth was about 1.5 m at maximum low tide, and the station was sampled at all tides except for maximum low.

Station 13. Nelson's Island. This station was located in the channel offshore of Nelson's Island and shoreline station 4 on the west side of Plum Island Sound. Equivalent to DMF's OS5. Depth was about 1.6 m at low tide, and the station was sampled at all tides except for maximum low.

Station 14. Cape Merrill. This station was located in the Plum Island River just beyond its confluence with the Parker River at the north end of Plum Island Sound. Equivalent to DMF's OS6. The substrate was sand and its minimum depth was about 1.35 m. The station was sampled at all tides.

Station 15. Entrance to Parker River. This station was located north of Dole Island where the Parker River enters Plum Island Sound. The substrate was sand, and it had a depth at low water of about 1.45 m. The station was sampled at all tides. DMF did not sample in this area.

Parker River Stations:

Station 16. Parker River. This station was on the Parker River between the Little and Mill Rivers, several hundred meters east of the railroad bridge. The substrate was mud. No equivalent DMF station was within 2 km in either direction. Depth at low water was about 1.5 m.

Station 17. Parker River. This station was two hundred meters to the west of the railroad bridge. The substrate was mud. The nearest DMF stations were OS8 (Mill River) and OS9 (South Shore). Depth at low water was about 1.5 meters. Sampling was carried out at mid to high tides.

Station 18. Parker River. This station was just east of the first meander in the river east of U.S. Route 1, approximately 0.8 km east of this road. The substrate was mud. This station was just west of DMF's OS9 (South Shore). Depth at low water was about 1.5 meters. Sampling was carried out at mid to high tides.

Station 19. Parker River. This station was several hundred meters west of Thurlow's Bridge (Middle Road). The substrate was mud. The nearest DMF station was OS10 (Thurlow's Bridge). Depth at low water was about 1.6 m, and this station was trawled at all tides.

Station 20. Parker River. This station was about two km west of Thurlow's Bridge (Middle Road). The substrate was mud. No DMF station was located in the immediate vicinity. Depth at low water was about 1.8 m, and this station was trawled at all tides.

Station 21. Parker River. This station was about one km east of the falls at Orchard and Central Street in Byfield. The substrate was mud. Depth at low water was about 1.2 m, and this station was trawled at all tides. This station was several hundred meters east of DMF's OS 11 (Woolen Mill), which in 1993/4 contained a number of underwater obstacles.

4.123. Identification, enumeration, and biomass of fish and decapods

Fish identifications were based on Bigelow and Schroeder (1953), Robins et al. (1986), Scott and Scott (1988) and an estuarine fish key developed by the Fish Ecology Laboratory of University of Massachusetts at Amherst (Basher 1989). Decapod crustaceans, including *Crangon septemspinosa*, *Palaeomonetes* spp. and crabs, were routinely collected in the MAS/WH study. These were identified using Smith (1964) and Gosner (1971, 1978). Fish numbers were expressed as fish per 100 m^2.

4.124. Comparison of results of the two studies

The areas covered by each seine haul done by DMF and MAS/WH were roughly the same (231 v 180). Jerome et al. (1968) carried out two seine hauls at each station on each date and presented results in the monograph as the sum of the two seine hauls. To make the data comparable, the results from the three seine hauls per station per date from the MAS/WH data were summed and then normalized to the same area swept as Jerome et al. by multiplying the sums by 0.667 to adjust for 2 v 3 seine hauls and then by 231/180 to adjust for the differences in area swept. Thus MAS/WH fish numbers x 0.85 represented the same area swept as Jerome et al. These numbers should be considered as catch per unit effort (CPUE) based on the assumption that the catch efficiencies of DMF and the MAS/WH studies were the same.

Another difference was that Jerome et al. sampled from January through December in 1965, whereas the MAS/WH monthly sampling began in June 1993, ran through December 1993, then continued from March - October 1994 (September 1994 was not sampled). Thus comparisons were made only between samples collected during the same months. 1993 and 1994 were considered two separate years and were not pooled together since they likely represent two different recruitment events for marsh fish.

DMF used their larger trawl for the more exposed stations near the mouth of Plum Island Sound, and the shrimp trawl for stations in the Parker River and more protected parts of the Sound. Since both their trawls were larger than that used by MAS/WH and DMF trawled for longer periods of time but used a larger mesh size, only qualitative comparisons (i.e. species lists) have been made. Since MAS/WH did not trawl at the Camp Sea Haven station (DMF’s station OS1) in Ipswich Bay, results from that station are not included in the comparison.

4.13. Results

Twenty-eight species of finfish were collected by DMF at the shore and offshore stations in Plum Island Sound and the Parker River in 1965 (Table 4.3). Thirty-four species were collected by the MAS/WH study in 1993/4. The species that were collected by DMF but not by MAS/WH included spiny dogfish, Atlantic sturgeon, Atlantic cod, sea raven, longhorn sculpin, Atlantic wolffish, ocean pout, yellowtail flounder, and goosefish. These were species from trawl samples, a number of which were caught at the Camp Sea Haven station (OS1) that was not sampled by MAS/WH. The species that were caught by MAS/WH but not by DMF included four species of herring, four freshwater species (golden shiner, banded killifish, yellow perch, and bluegill), brown trout, one stickleback species (black-spotted), grubby, striped bass, bluefish, cunner, rock gunnel, and one species (moonfish) from southern waters.

Table 4.3. A check list of finfish species collected at all sampling stations in the Parker River-Plum Island Sound Estuary, 1965 (DMF study) and 1993/4 (MAS/WH study). The year(s) at which the fish were observed is noted.

Class & Order	**Family**	**Genus & Species**	**Common Name**	**Years seen** 1965	1993/4
CHONDRICHTHYS					
Squaliformes	Squalidae	*Squalus acanthias*	spiny dogfish	X	
Rajiformes	Rajidae	*Raja erinacea*	little skate	X	
		Raja ocellata	winter skate	X	
		Raja spp.	skate species		X
OSTEICHTHYS					
Acipensiformes	Acipenseridae	*Acipenser oxyrhynchus*	Atlantic sturgeon	X	
Clupeiformes	Clupeidae	*Alosa aestivalis*	blueback herring	X	X
		Alosa pseudoharengus	alewife	X	X
		Alosa sapidissima	shad		X
		Brevoortia tyrannus	Atlantic menhaden		X
		Clupea harengus	Atlantic herring		X
		Opisthonema oglinum	thread herring		X
	Osmeridae	*Osmerus mordax*	American smelt	X	X
	Salmonidae	*Salmo trutta*	brown trout		X
Cypriniformes	Cyprinidae	*Notemigonus chrysoleucus*	golden shiner		X
Anguiliformes	Anguillidae	*Anguilla rostrata*	American eel	X	X
Cyprinodontiformes	Cyprinodontidae	*Fundulus heteroclitus*	mummichog	X	X
		Fundulus diaphanous	banded killifish		X
Gadiformes	Gadidae	*Gadus morhua*	Atlantic cod	X	
		Microgadus tomcod	Atlantic tomcod	X	X
		Urophycis spp..	hake	X	X
Gasterosteiformes	Gasterosteidae	*Apeltes quadricus*	four-spined stickleback	X	X
		Gasterosteus aculeatus	three-spined stickleback	X	X
		Gasterosteus wheatlandi	black-spotted stickleback		X
		Pungitius pungitius	nine-spined stickleback	X	X
	Syngnathidae	*Syngnathus fuscus*	northern pipefish	X	X
Perciformes	Percicthyidae	*Morone americanus*	white perch	X	X
		Morone saxatilis	striped bass		X
	Centrarchidae	*Lepomis macrochirus*	bluegill sunfish		X
	Percidae	*Perca flavescens*	yellow perch		X
	Pomatomidae	*Pomatomus saltatrix*	bluefish		X
	Carangidae	*Vomer setapinnus*	moonfish		X
	Labridae	*Tautogolabrus adspersus*	cunner		X
	Ammodytidae	*Ammodytes americanus*	American sand lance	X	X
	Cottidae	*Hemipterus americanus*	sea raven	X	
		Myoxocephalus octodecemspinousus	longhorn sculpin	X	
		Myoxocephalus aenaeus	grubby		X
	Cyclopteridae	*Cyclopterus lumpus*	lumpfish	X	X
	Anarhichadidae	*Anarhichus lupus*	Atlantic wolffish	X	
	Zoarcidae	*Macrozoarces americanus*	ocean pout	X	
	Atherinidiae	*Menidia menidia*	Atlantic silversides	X	X
	Pholidae	*Pholis gunnellus*	rock gunnel		X
Pleuronectiformes	Bothidae	*Scopthalmus aquosus*	windowpane	X	X
	Pleuronectidae	*Limanda ferruginea*	yellowtail flounder	X	
		Pleuronectes americanus	winter flounder	X	X
Lophiformes	Lophiidae	Lophius americanus	goosefish	X	

The 34 species of finfish collected by MAS/WH represented 143,616 individuals. The total number of individual fish collected by DMF was 10,790.

4.131. Shore stations: Comparison of 1993/4 and 1965 data

The 1965 study by DMF was carried out over the course of one year. In order to make the MAS/WH data more directly comparable, data only from the first year of the MAS/WH study (i.e., from June 1993 through May 1994) were used when calculating the average number of fish per 100 m^2.

Fish numbers and species richness - There was a large difference in the number of fish caught by beach seining in 1993/4 compared to the 1965 DMF study (Table 4.4). The average CPUE of fish was about 6 times higher in 1993/4 compared to 1965 (2521 v 405 per 100m^2). This large increase is attributable to a 5-fold increase in mummichogs and a 11 fold increase in Atlantic silversides, the two most common species in both studies. Aside from these two species of "bait fish", the number of other species did not differ very much between the two studies. The 4-fold increase in "river" herring is largely the result of a particularly large catch on one sample day rather than a consistent overall increase throughout the course of the study. Two species that have apparently declined based on the differences in the two studies are three-spined sticklebacks (*Gasterosteus aculeatus*) and rainbow smelt (*Osmerus mordax*). It is clear that the fish community in 1993/4 is even more dominated by mummichogs and Atlantic silversides relative to other species than it was in 1965 (Fig. 4.2a-b).

Since MAS/WH collected data from two summers, the total number of fish caught in each year of that study were compared to the 1965 study (Fig. 4.3). Although numbers of fish were generally higher at most seining stations in 1993 compared to 1994 (compare for example July), fish numbers were higher in both years of our study than in 1965. Species richness based on beach seining was higher in the MAS/WH study compared to the earlier study - 15 vs. 13 species (Table 4.4).

This large increase in fish in Plum Island Sound and the Parker River noted for the entire water body in the 1965 v 1993/4 study occurred at all sampling stations as well (Tables 4.5-4.10). Once again this was primarily related to increases in silversides and mummichogs. Silversides were higher in numbers in 1993/4 compared to 1965 at all stations, the increase ranging from 2.3 times at Newbury Landing to 57 times at Little Neck and 62 times at Nelson's Island. Mummichogs increased at four of the six stations sampled by both us and DMF, increasing 56 times at Great Neck, but declining substantially at the Bluffs and slightly at Nelson's Island.

Table 4.4. Difference in the catch per unit effort of fish by DMF in 1965 and the MAS/Woods Hole study from June 1993 through May 1994. Averages for all shoreline stations sampled with beach seines. Numbers are expressed as individual fish per 100 m^2 to normalize for slight differences in sampling areas during seining.

Year of study

Table 4.4

Species	*1965*	*1993/4*
mummichog	18.402	128.972
Atlantic silverside	5.834	110.006
ninespine stickleback	2.115	2.455
threespine stickleback	0.942	0.325
river herring	0.673	4.107
rainbow smelt	0.393	0.187
American sand lance	0.190	
fourspine stickleback	0.027	0.028
Atlantic cod	0.023	
winter flounder	0.020	0.157
northern pipefish	0.010	0.061
longhorn sculpin	0.003	
Atlantic tomcod	0.003	0.015
blackspotted stickleback		0.123
hake		0.006
bluefish		0.006
grubby		0.018
American eel		0.006
	28.635	246.436

Fig. 4.2a. Distribution of fish caught by seine, DMF 1965 survey.

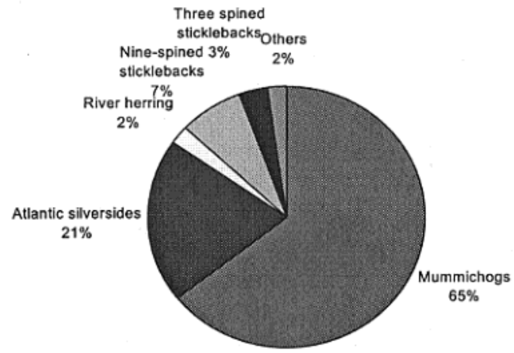


Fig. 4.2b. Distribution of fish caught by MAS/WH at shoreline stations. 1993-4.

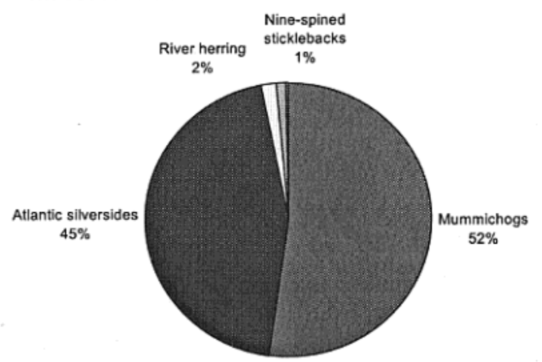
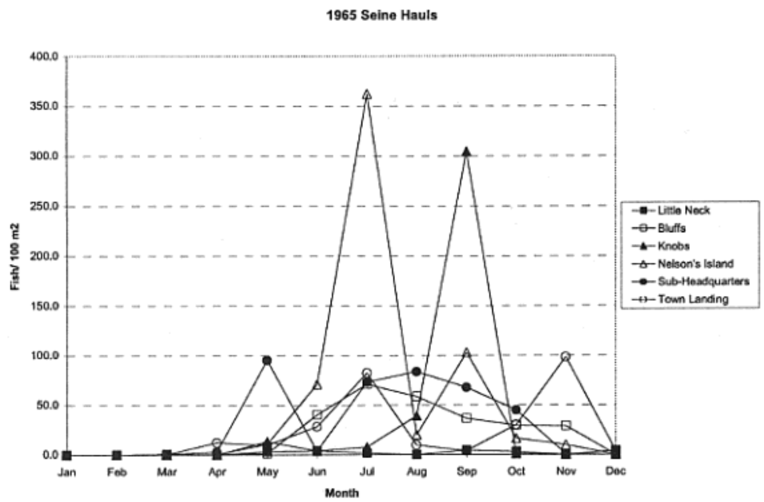
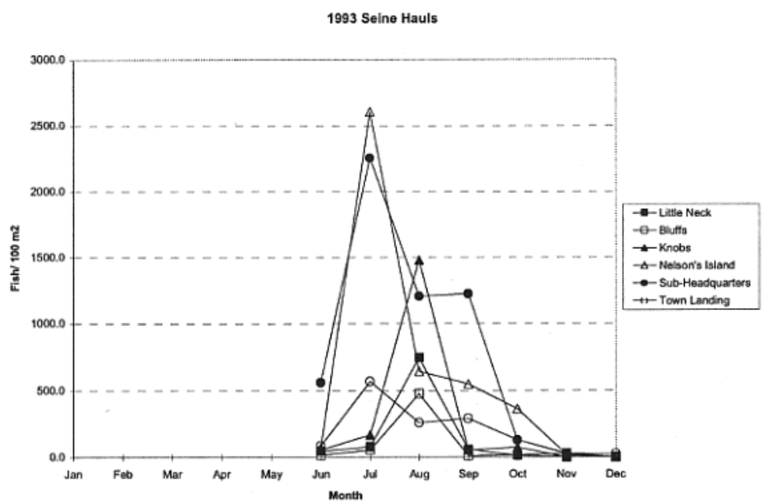


Fig. 4.3. Yearly comparison of fish numbers over months of both studies





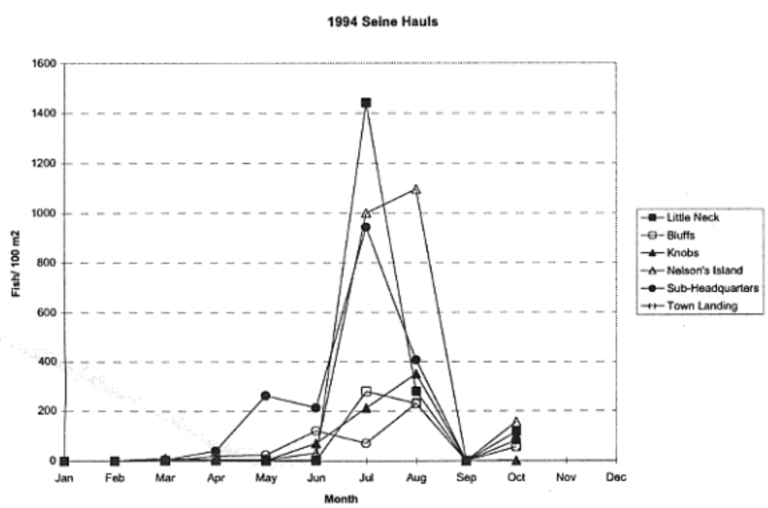


Table 4.5. Catch per unit effort (CPUE) of fish using beach seines at Little Neck, Ipswich. DMF Station S1. MAS/WH Station 1. Numbers are # fish caught per 100 m^2 of area swept by beach seines. This is averaged over a full year of monthly sampling for both studies. Percents are % of catch.

Common name	1965		1993/4	
	number	percent	number	percent
Atlantic silverside	0.541	32.3	39.411	50.0
mummichog	0.451	26.9	32.366	41.1
3-spine stickleback	0.325	19.4	0.261	0.3
9-spine stickleback	0.198	11.8	6.384	8.1
Atlantic cod	0.108	6.5	0.000	0.0
winter flounder	0.018	1.1	0.015	0.0
rainbow smelt	0.018	1.1	0.123	0.2
longhorn sculpin	0.018	1.1	0.000	0.0
northern pipefish	0.000	0.0	0.153	0.2
grubby	0.000	0.0	0.077	0.1
black-spotted stickleback	0.000	0.0	0.031	0.0
hake sp.	0.000	0.0	0.015	0.0

Table 4.6. CPUE at Bluffs, Ipswich. DMF Station S2. MAS/WH Station 2. Numbers as in Table 4.5.

Common name	1965		1993/4	
	number	percent	number	percent
mummichog	9.697	36.3	0.221	0.4
9-spine stickleback	7.403	27.7	1.179	1.9
Atlantic silverside	5.714	21.4	58.029	95.3
3-spine stickleback	3.874	14.5	0.239	0.4
blackspotted stickleback	0.000	0.0	0.589	1.0
winter flounder	0.000	0.0	0.460	0.8
Atlantic tomcod	0.000	0.0	0.074	0.1
northern pipefish	0.000	0.0	0.037	0.1
rainbow smelt	0.000	0.0	0.018	0.0
grubby	0.000	0.0	0.018	0.0

Table 4.7. CPUE at Knobs, Rowley. DMF Station S3. MAS/WH Station 3. Numbers as in Table 4.5.

Common name	1965		1993/4	
	number	percent	number	percent
mummichog	31.948	86.3	93.867	51.3
Atlantic silverside	1.883	5.1	84.033	46.0
rainbow smelt	1.710	4.6	0.000	0.0
3-spine stickleback	1.234	3.3	0.074	0.0
9-spine stickleback	0.173	0.5	4.457	2.4
winter flounder	0.043	0.1	0.313	0.2
northern pipefish	0.022	0.1	0.055	0.0
blackspotted stickleback	0.000	0.0	0.018	0.0
American eel	0.000	0.0	0.018	0.0
4-spine stickleback	0.000	0.0	0.018	0.0

Table 4.8. CPUE at Nelson's Island Shoreline Station. DMF Station S4. MAS/WH Station 4. Numbers as in Table 4.5.

Common name	1965		1993/4	
	number	percent	number	percent
mummichog	46.006	87.5	59.061	13.8
Atlantic silverside	4.191	8.0	367.403	86.0
river herring	1.555	3.0	0.000	0.0
3-spine stickleback	0.374	0.7	0.239	0.1
rainbow smelt	0.256	0.5	0.074	0.0
9-spine stickleback	0.118	0.2	0.129	0.0
4-spine stickleback	0.039	0.1	0.037	0.0
Atlantic tomcod	0.020	0.0	0.000	0.0
northern pipefish	0.020	0.0	0.000	0.0
blackspotted stickleback	0.000	0.0	0.055	0.0
bluefish	0.000	0.0	0.037	0.0
winter flounder	0.000	0.0	0.037	0.0

Table 4.9. CPUE at Subheadquarters. DMF Station S5. MAS/WH Station 5. Numbers as in Table 4.5.

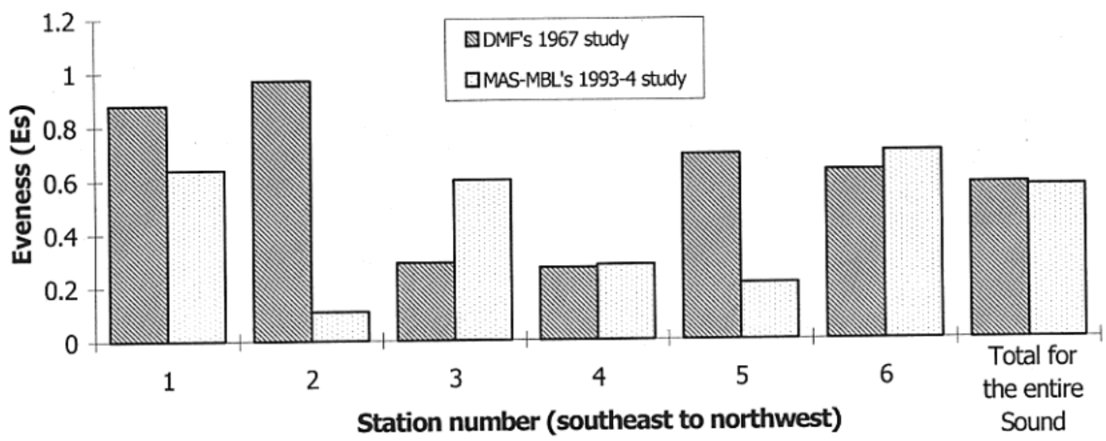
Common name	1965		1993/4	
	number	percent	number	percent
mummichog	19.589	55.7	514.770	90.2
Atlantic silverside	8.550	24.3	54.420	9.5
9-spine stickleback	4.524	12.9	0.829	0.1
river herring	2.121	6.0	0.000	0.0
3-spine stickleback	0.173	0.5	0.681	0.1
4-spine stickleback	0.130	0.4	0.018	0.0
rainbow smelt	0.065	0.2	0.000	0.0
winter flounder	0.022	0.1	0.018	0.0
northern pipefish	0.022	0.1	0.000	0.0
blackspotted stickleback	0.000	0.0	0.018	0.0

Table 4.10. Newbury Town Landing. DMF Station S6. MAS/WH Station 6. Numbers as in Table 4.5.

Common name	1965		1993/4	
	number	percent	number	percent
Atlantic silverside	13.763	60.3	48.858	34.2
mummichog	6.025	26.4	67.072	47.0
9-spine stickleback	1.064	4.7	0.479	0.3
American sand lance	1.028	4.5	0.000	0.0
rainbow smelt	0.397	1.7	0.884	0.6
river herring	0.451	2.0	24.641	17.3
3-spine stickleback	0.036	0.2	0.405	0.3
winter flounder	0.036	0.2	0.092	0.1
Atlantic cod	0.018	0.1	0.000	0.0
northern pipefish	0.000	0.0	0.092	0.1
4-spine stickleback	0.000	0.0	0.092	0.1
American eel	0.000	0.0	0.018	0.0
blackspotted stickleback	0.000	0.0	0.018	0.0
Atlantic tomcod	0.000	0.0	0.018	0.0

Evenness - The more complete domination of the Plum Island Sound fish community by two species in 1993/4 compared to 1965 might lead to the conclusion that diversity had declined at the shoreline stations. This was examined by looking at Ecological Evenness (E_S). E_S is based on the Simpson diversity index and is the ratio of the actual diversity to the maximum possible diversity if individuals were completely evenly distributed among all species. Surprisingly, the overall evenness for the entire Sound did not decline, although it did decline in a number of the stations (Fig. 4.5). Station 2 which had a sharp increase in silversides and station 5 which had an order of magnitude increase in mummichogs experienced the steepest decline in E_S from 1965 through 1993/4.

Fig. 4.4. Comparison of ecological eveness - Simpson Index.



4.132. Trawl stations

The MAS/WH 1993/4 study caught a higher number of species at DMF's shrimp trawl stations than did DMF in 1965 (33 v 13 species, Table 4.11). These stations were in the northern part of Plum Island Sound and the Parker River. The studies are not directly comparable quantitatively since DMF used a larger trawl with a larger mesh size and trawled for long periods of time.

Table 4.11. Species caught in shrimp trawl by DMF in 1965 and the MAS/WH 1993/4 study of Plum Island Sound. The stations included in this table are DMF's OS4-OS11 and MAS/WH's stations 13-22, all in the northern part of Plum Island Sound and the Parker River.

Species	**1965 DMF Study**	**1993/4 MAS/WH Study**
skate species	X	X
river herring	X	X
shad		X
Atlantic menhaden		X
Atlantic herring		X
thread herring		X
American smelt	X	X
brown trout		X
golden shiner		X
American eel	X	X
mummichog	X	X
banded killifish		X
Atlantic tomcod	X	X
hake	X	X
four-spined stickleback		X
three-spined stickleback		X
black-spotted stickleback		X
nine-spined stickleback		X
northern pipefish	X	X
white perch	X	X
striped bass		X
bluegill sunfish		X
yellow perch		X
bluefish		X
moonfish		X
cunner		X
American sand lance		X
sea raven		
longhorn sculpin	X	
grubby		X
lumpfish	X	X
Atlantic silversides		X
rock gunnel		X
windowpane	X	X
winter flounder	X	X

Differences in gear type also make it difficult to compare the fish caught at individual trawl stations. Not surprisingly, the differences in species caught is most striking at the two stations where DMF sampled with their large trawl for twenty minutes using the *Peggybell* and MAS/WH sampled for two minutes with their smaller trawl (Tables 4.12-4.13).

Table 4.12. Castle Neck Offshore Station (DMF OS2, MAS/WH Station 10). Total number of fish caught over a one year time period. DMF used a trawl with a sweep of 14.8m and a mesh size of 12.7 cm in the wings and 10.2 cm in the cod end. MAS/WH's trawl had a sweep of 4.9 m and a mesh size of 1.91 cm in the wings and 0.48 cm in the cod end.

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Table 4.13. Middle Ground Offshore Station (DMF OS4, MAS/WH Station 12). Total number of fish caught over a one year time period.

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4.133. Macroinvertebrates

The MAS/WH study kept records of several species of macroinvertebrates caught with the beach seine and shrimp trawl along with finfish (Table 4.14). They recorded a total of 131,909 macroinvertebrates, most of which were the sand shrimp, *Crangon septemspinosa* (130,141). Eighty-seven percent of their beach seining samples included at least one sand shrimp. Other frequently caught macroinvertebrates were the grass shrimp, *Palaeomonetes pugio;* green crab, *Carcinus maenus*; and white fingered mud crab, *Rhithropanopeus harrissi*.

Table 4.14. Frequency of occurrence of macroinvertebrates in seine and trawl samples.

	Beach Seine		Shrimp Trawl	
	frequency caught	percent frequency*	frequency caught	percent frequency*
sand shrimp	249	84.69%	152	33.78%
grass shrimp	93	31.63%	23	5.11%
green crab	44	14.97%	32	7.11%
rock crab	21	7.14%	28	6.22%
lady crab	2	0.68%	3	0.67%
white-fingered mud crab	0	0.00%	72	16.00%
horseshoe crab	0	0.00%	2	0.44%
Say's mud crab	0	0.00%	2	0.44%

*Percent frequencies based on a total of 294 seine tows and 450 trawls

4.134. Overall patterns of species distribution

The overall distribution of fish and decapod species in Plum Island Sound reflects differences in habitat types within this body of water (Table 4.15). The lower part of the Sound consists mostly of sandy substrate. These areas tend to be dominated by Atlantic silversides and sand shrimp. Mummichogs are also quite abundant. Mud flats closely associated with salt marshes are also dominated by these three species plus grass shrimp. The Parker River, which becomes increasingly brackish upriver, has a different assemblage of organisms, dominated by white perch and white fingered mud crab. Anadromous species, particularly "river herring" (alewives and blueback herring) were also frequently caught within the river.

Table 4.15. Dominant organisms associated with different habitats within Plum Island Sound

Open water with sandy substrata
- Atlantic silversides
- mummichogs
- sand shrimp

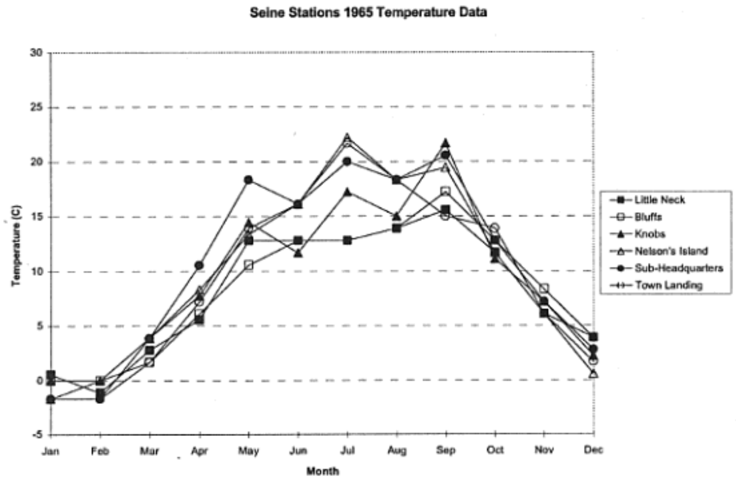
Muddy salt marsh habitats
- mummichogs
- Atlantic silversides
- sand shrimp
- shore shrimp

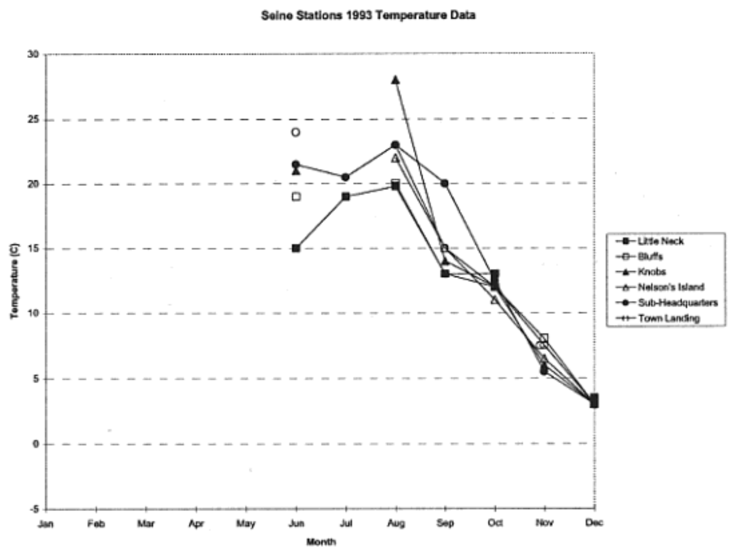
Brackish riverine habitats
- white perch
- river herring
- white-fingered mud crab

4.135. Measurements of physical parameters

Water temperatures were higher at most stations in the MAS/WH study compared to the DMF study for the three summer months and in April (Fig. 4.5). Spring and autumn salinities were much lower in our study, and this was particularly pronounced at two stations that were the most closely associated with riverine discharge: the Town Landing (Station 6) which is on the Parker River and Nelson's Island (Station 4), which is just downstream from the Parker (Fig. 4.6). Not surprisingly higher springtime riverine discharges occurred in the region in the springs of 1993 and 1994 compared to 1964 and 1965, (Fig. 4.7) based on United States Geological Survey discharge data from gauging stations on the Parker and Ipswich Rivers.

Fig. 4.5. Water temperature over time of two studies





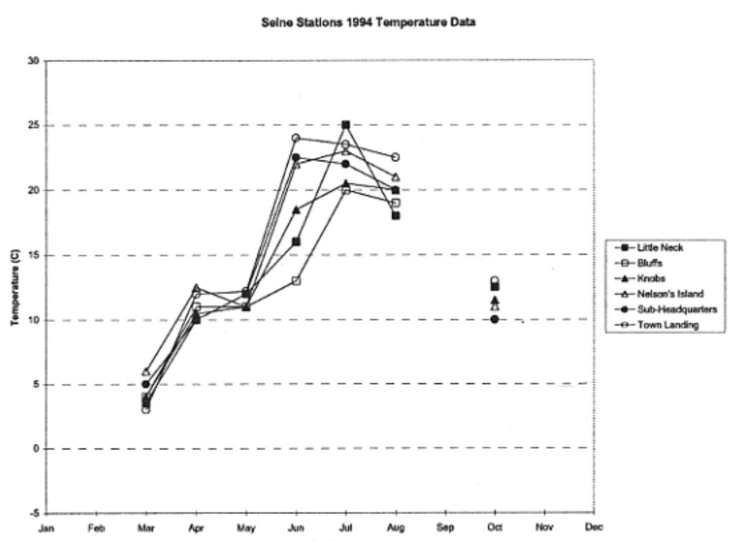
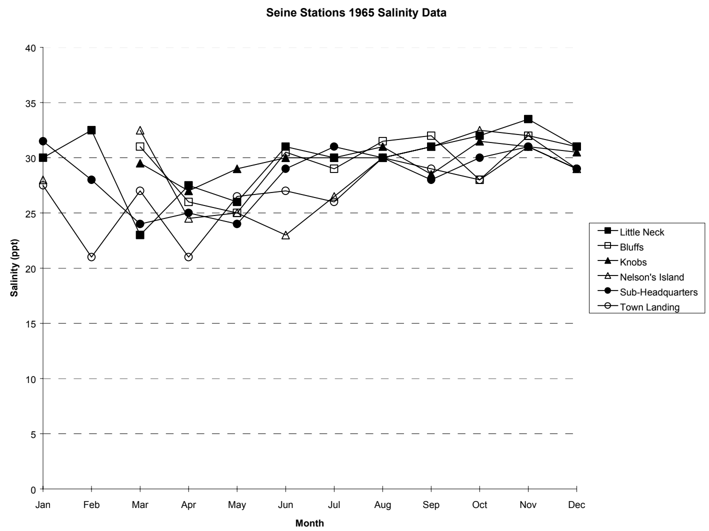
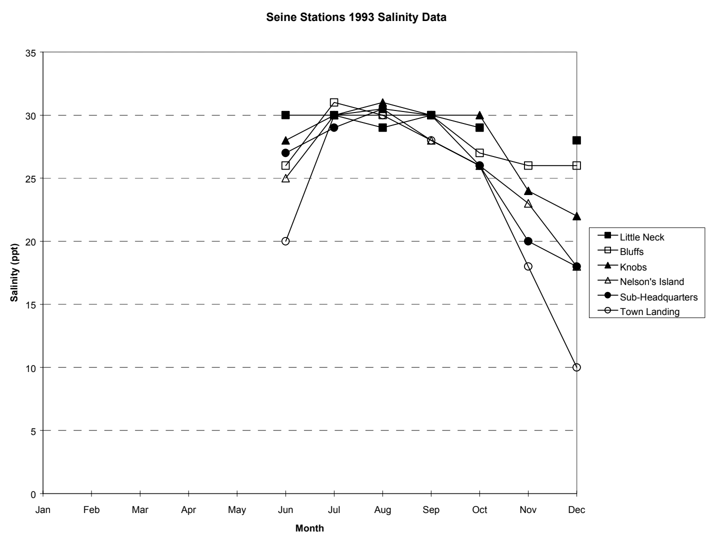


Fig. 4.6. Salinities over time of two studies





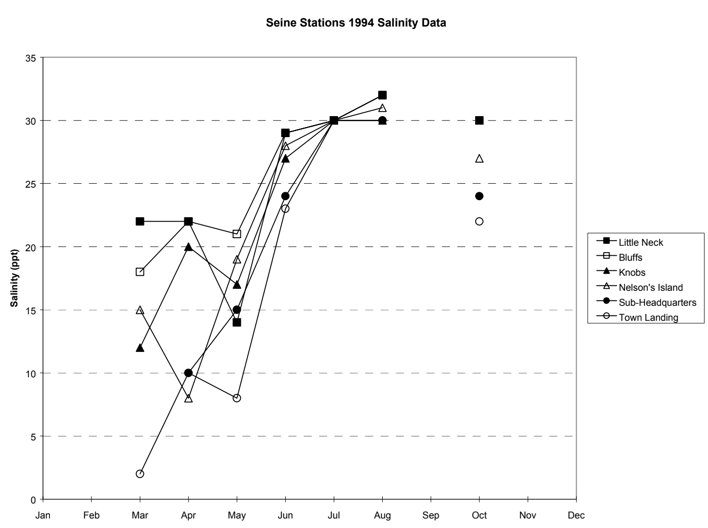
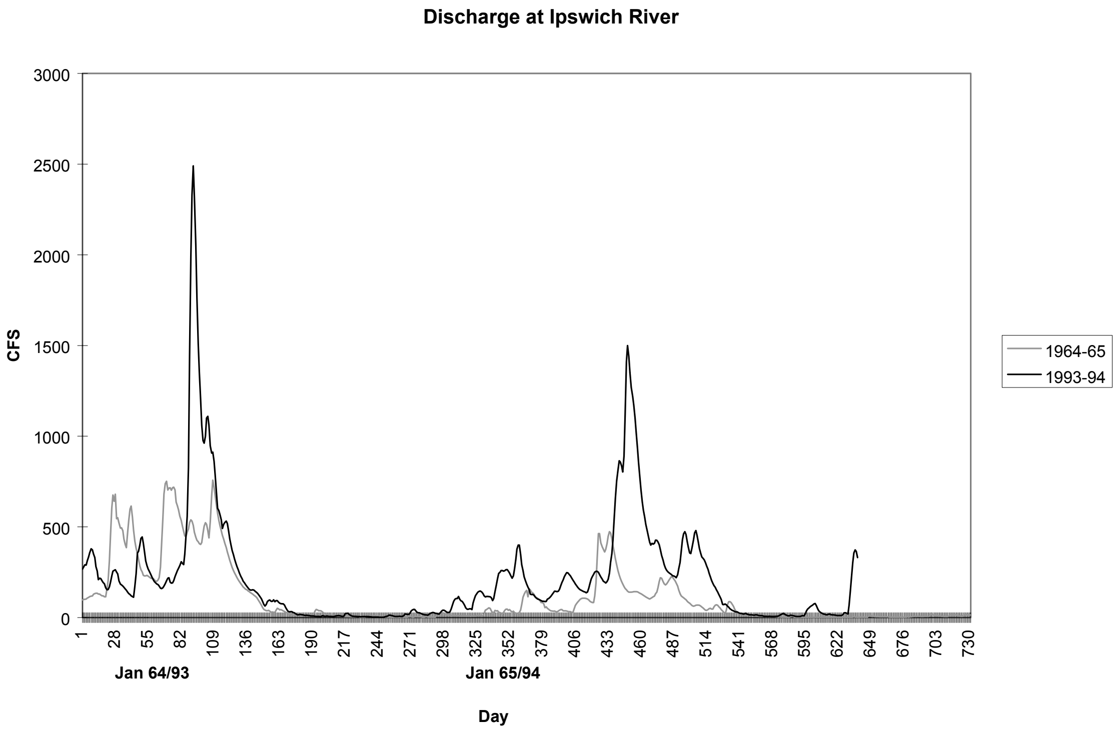
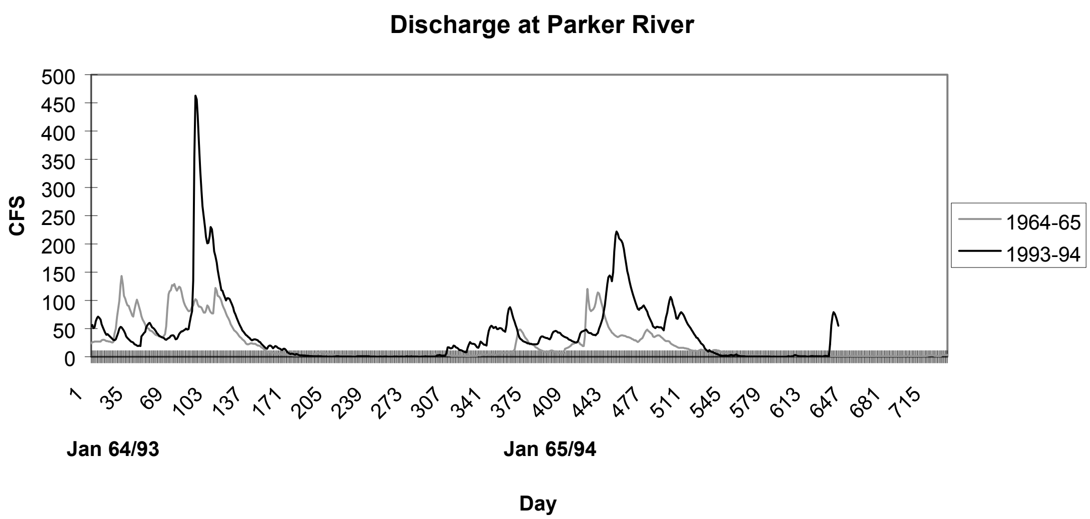


Fig. 4.7 Daily discharge at Ipswich and Parker Rivers over time of two studies





4.14. Discussion

4.141. The reason for differences between the two studies

The large increase in the number of total fish found by beach seining in Plum Island Sound and the Parker River in 1993/4 compared to that found by DMF in 1965 was the result of 6 and 11-fold increases in mummichogs and Atlantic silversides respectively. The major differences between the two studies occurred in summer months. The obvious question is whether this was the result of methodological differences or was a real response to local or regional changes in the habitat.

Differences in methodologies - We do not believe that the substantial differences between the two studies in the number of fish caught by beach seining were the result of differences in methodologies. Both the MAS/WH and DMF studies used 15.2 m beach seines with a central bag. If anything, the slight differences in methods should have favored a greater catch for DMF since DMF used a smaller mesh size (3.2 mm v 4.8 mm). The only station that was somewhat different in exact location was station 1. DMF's Little Neck station had patches of small cobbles and shells in 1993/4 that made it difficult to reliable keep the lead line of the net on the bottom. This was why MAS/WH moved station 1 several hundred meters north to a smoother beach and renamed it Great Neck. Although MAS/WH did catch more fish at this new seining station than did DMF in the earlier study, they also caught more fish at every other station as well.

Differences in physical parameters - The period in which DMF carried out their survey was characterized by higher salinities and lower freshwater discharges to the Sound than in the MAS/WH study. Mummichogs and silversides are tolerant of a wide range of salinities so its doubtful that differences in salinities alone could explain such a large increase in the number of fish caught. According to Bigelow and Schroeder (1953), Atlantic silversides need summer temperatures as high as about 20^{o}C for successful spawning, so the lower water temperatures recorded in 1964 compared to 1993-1994 may have resulted in reduced spawning success, assuming the lowered temperatures recorded once a month on sampling days reflected patterns throughout the entire summer.

Random fluctuations - It is possible that fish numbers fluctuate drastically from year to year and that the two studies happened to cover different extremes of a natural cycle. If such a cycle does exist, it likely extends for a longer period than one year, since two summers of data both indicated higher numbers of fish in 1993/4 compared to the 1965. The possibility that there are such drastic natural variability in fish numbers cannot be ruled out, and hopefully future monitoring can contribute information that would assess its plausibility.

Local changes in the ecosystem - Fish communities are very sensitive to changes in estuarine habitat quality. Deegan et al. (1993) has developed metrics based on a number of aspects of fish communities that are influenced by water quality parameters, particularly eutrophication. These fish community metrics can then be used to assess the biological integrity of an estuary. Deegan et al. (1993) found a similar increase in "bait fish" in Waquoit Bay on Cape Cod based on a comparison of a 1960s DMF assessment and recent sampling. The Waquoit Bay watershed has undergone rapid development between the time period of the two fish surveys and much of the change in fish communities may be related to the resultant eutrophication and habitat degradation.

In contrast to Waquoit Bay and many other east coast estuaries, Plum Island Sound has remained relatively pristine in the last 25 years. There is no indication that eutrophication is an issue in the Sound itself at this time. Nitrogen loading has likely increased in the largest watershed draining into the Sound, the Ipswich River, due to the extensive suburban growth in some upstream communities, however most of this nitrogen is apparently filtered out in an extensive wetlands system before it ever reaches the Sound (C. Hopkinson, unpublished results of the LMER project). Some smaller streams, such as Ox Pasture Brook in Rowley have serious water quality issues (see water quality chapter), and these may have had effects on the spawning of anadromous and freshwater species in those particular water bodies. B. Chase (pers. comm.) of DMF has suggested that algal growth in some tributaries has degraded the spawning sites of rainbow smelt and thereby contributed to the decline of this once thriving recreational fishery in the region. Despite degradation in certain tributaries, the overall loading of nutrients to the Sound itself from these smaller tributaries is by all indications negligible. Yet the results indicate that, like Waquoit Bay, the fish community of Plum Island Sound has still changed since the 1960s even without any obvious environmental degradation.

One speculation is that mosquito control practices may have impacted the populations of silversides and mummichogs in estuaries in the 1960s. Pesticide used for mosquito control on salt marshes likely included DDT or other chlorinated hydrocarbons. These may have impacted small fish, many of which are very susceptible to many insecticides. DMF found DDT residues in concentrations of 0.132 and 0.246 ppm (live body weight) of body muscle tissue from two white perch analyzed as part of the 1968 Plum Island Sound report. No such residues were present in winter flounder. Four finfish from the Merrimack River estuary had DDT residues ranging from 0.8 to 10 ppm. It is possible that pesticide sampling of mummichogs and silversides might have revealed the presence of pesticide residues in the 1960s and that this may have played a role in their relatively small numbers compared to what was recorded in the 1990s. Although pesticides are still sprayed on the marshes for mosquito control, the ones used in the 1990s, such as malathion and resmethrin, are less persistent, and the spraying is likely less widespread than in the past due to budgetary and environmental concerns from the local communities.

Regional changes - The similarity of changes in the fish community at both Waquoit Bay and Plum Island Sound since the 1960s raises the possibility that both estuaries are responding to regional changes that are occurring within New England. A number of changes in populations of predators on small fish may be at least partially responsible for the results, although as discussed below, the relationship is not entirely clear.

One of the most obvious, recent ecosystem changes experienced by all of New England is the severe decline in groundfish as a result of overfishing by the New England fishing fleet. Some groundfish could have been significant predators on small estuarine fish. Bigelow and Schroeder (1953) list silversides as one of the small fish that are routinely part of the diet of Atlantic cod. The 1960s were also a time of intense overfishing, at that time by foreign vessels whose major groundfish target was haddock (Murawski, in prep.). All groundfish populations in the 1990s have been particularly low thus the loss of piscivorous fish may at least partly explain the apparent population "boom" of small fish in both estuaries.

Striped bass, a major estuarine predator on small fish, was still relatively abundant in the 1960s, and is therefore not likely to have been responsible for differences between fish populations in the 1960s and the 1990s. This fish experienced a crash in the 1970s and a recovery in the 1990s,

Certain species of piscivorous birds have also declined since the 1960s. Populations of tern, which feed on small fish, are down across New England and within the Plum Island region (see bird chapter). The populations of other aquatic birds, such as cormorants, herons, and egrets, that also eat small fish, have increased in the region over the same time period, so it is not clear what the net effect on estuarine fish has been.

4.142. The importance of sand shrimp to Plum Island Sound trophic dynamics

The large number of sand shrimp (*Crangon septemspinosa*) caught in beach seines, and its frequent presence in both seines and trawls points to the importance of this species within the Plum Island Sound estuary. Larger individuals filled the stomach of one striped bass examined in the MAS/WH study, and smaller individuals were a common item in the stomachs of silversides, mummichogs, windowpane flounder, and rainbow smelt. This shrimp is omnivorous, feeding on algae, small animals, and detritus. It clearly plays a major role in the transfer of energy from both benthic algae and detritus to higher trophic levels.

4.143. Future research needs

The differences between the results of 1965 and those in 1993/4 points to the need for more frequent monitoring of the biological communities of Plum Island Sound and other estuaries. Although a number of possible explanations for the differences have been described, more frequent monitoring is needed to adequately explain whether there has been a trend caused by regional environmental factors over the thirty years between the two studies or whether fish populations, particularly those of mummichogs and silversides, naturally exhibit temporal variability within the ranges of the MAS/WH and DMF studies.

4.2. River Herring

by David Mountain, Parker River Clean Water Association

4.21. Commercial Landings

Belding (1921) documented the establishment of a public in-river alewife fishery in 1793 with an annual production of approximately 100 barrels. Beldings' report chronicled other important landmarks in the history of both the management and abuse of the Parker River alewife resource. The first fishing restrictions were established in 1793 limiting the fishing period, net size, number and mesh. In 1805 provisions were made for fish passage at dams. In 1808 the Town of Newbury appointed a herring committee that immediately enacted regulations concerning the location of where herring could be harvested as well as the prohibition of ice fishing. The fact that a herring committee was established and regulations were adopted indicates that the annual herring run was important to the local residents.

Massachusetts commercial landings of alewives peaked in 1958 at 33,814,700 pounds and then dropped dramatically in the late 1960's. The decline continued through the 70's and 80's to the point where the 1990-93 average was only 19,650 pounds.

4.22. Dams

The annual migration of alewives and other anadromous fish in the Plum Island Sound basin has been hampered by dams for over three centuries. In 1636, a year after the first European settlement along the Parker River, a dam for a sawmill was built at the lower falls (Central Street). About the same time a grist mill was built in Ipswich. The Mill River in Rowley was dammed in 1643 and the Egypt River in 1687. By the early 19th century, all the usable tributaries appear to have been dammed and the Parker River had at least seven dams on the mainstem.

The Massachusetts General Court attempted to improve the declining fish populations by passing an act on March 8, 1806 that required Mill owners to make a way sufficient for the passage of fish over their mill dams. It directed them to keep the fishway open and well supplied with water from the fifteenth of April to the first of June.

According to Belding (1921), the construction of dams without adequate provisions for fish passage and the decline of water quality in the rivers caused a considerable reduction in the alewife population within the study area. Belding implied in his report that the alewife fishery in the study area could be restored by the construction of fishways at the dam sites along the rivers.

4.23. Fishways

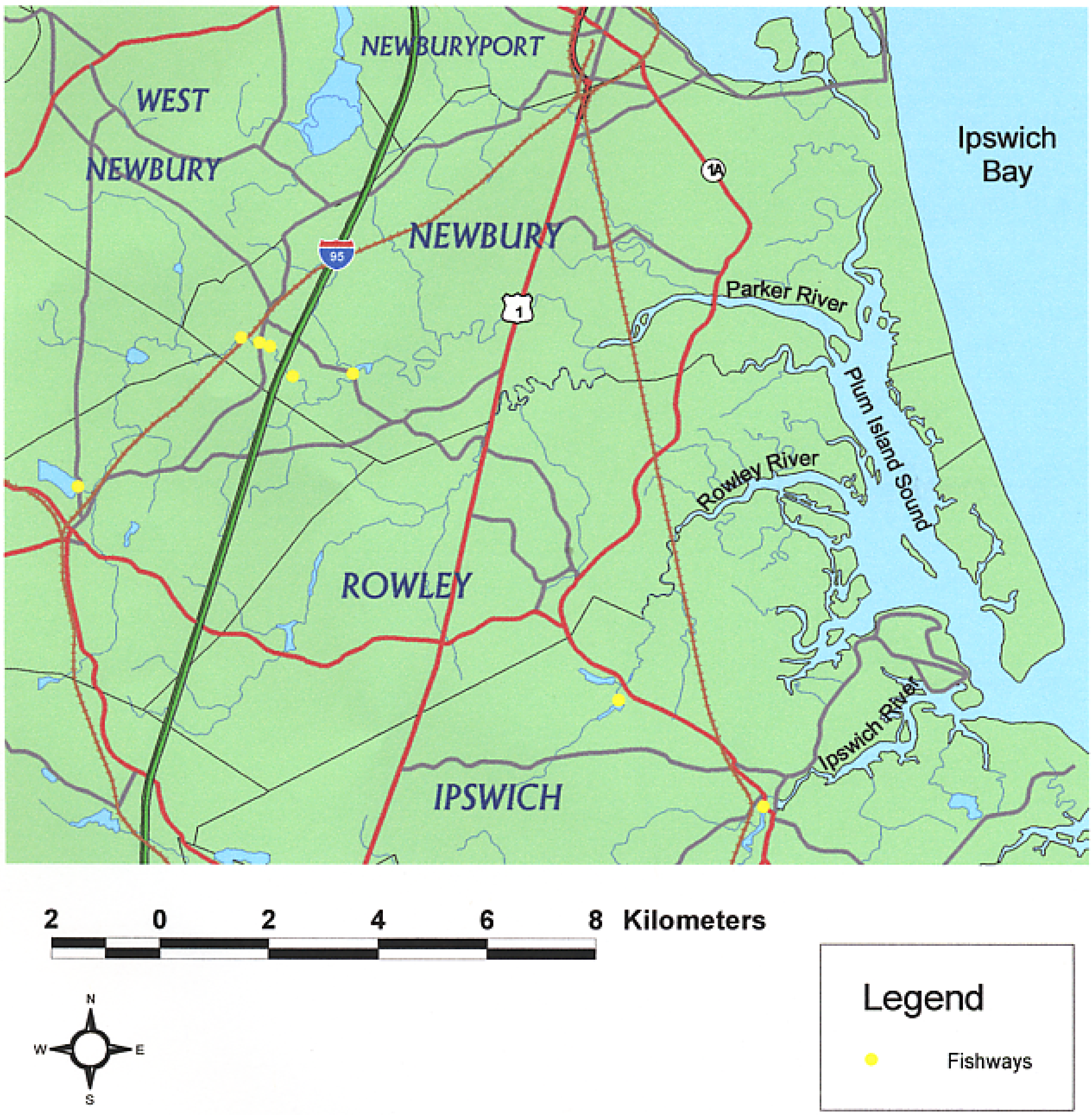
Since Belding's report, fishways have been constructed at six locations along the Parker River leading to Pentucket Pond in Georgetown (Fig. 4.8). With the exception of the relatively new fishway and dam at the outlet of Pentucket Pond, the fishways were built during the 1930's with the aid of Works Progress Administration (WPA) funds. The condition of these fishways is summarized in Table 4.16.

Table 4.16. Description and Condition of Fishways in the Parker River, 1997.

			DAM			FISHWAY			CONTROL BOX		
Fishway Number	Town	Owner	length	Height	Condition	length	No. Of Steps	Condition	Size	Flash Boards	Condition
1	Byfield	Byfield Water District	45'	18'	?	100'	12	repaired 1997	3'x3'x11'	satis-factory	good
2	Byfield	Town of Newbury	45'	8'	Poor	125'	13	repaired 1997	3'x3'x11	missing	repaired 1997
3	Byfield	J. Beck	65'	12 "	Good	105'	11	needs repairs + cleaning	3'x3'x11'? ?	missing	?
4	Byfield	J. Batchelder	75'	18'	Good	335', but now bypassed	21	Alaskan Steep Pass installed in 2000	3'x3'x11	missing	?
5	Byfield	B. Pearson	35'	12'	Needs new cap?	55'	9	needs repairs + cleaning	3'x3'x11	missing	?
6	Georgetown	Town of Georgetown	7 1/2'	14	?	10'	5	rebuilt 2000	no control box		

All fishways needed repairs at the time of the 1968 report by Jerome et al. In the late 1990s, a number of organizations and agencies working together under the Great Marsh Initiative have promoted improvements. Some repairs to sites #1 and #2 were done in 1997 through funding from the Eight Towns and The Bay Committee. For several years, the Essex County Sportsmen's Association annually installed a wooden temporary fishway to get the alewives over the dam at Pentucket Pond (site #6) during the run. In 1999, the town of Georgetown rebuilt this dam and fishway completely, with guidance from the Division of Marine Fisheries and the U.S. Fish and Wildlife Service. Minor adjustments still need to be completed to optimize fish passage. The fishway at site #4 was replaced in November 2000 by an Alaskan Steep Pass installed right into the face of the dam with funding secured by the NOAA Restoration Center and FishAmerica Foundation. These improvements, some additional work on other fishways, and continued maintenance will hopefully lead to enhancement of the alewife run.

Fig. 4.8. Location of Fishways in the Plum Island Sound Area



In 1965, an alewife fishway and pond were constructed by the Town of Ipswich at the confluence of Bull and Dow Brooks by the municipal electric generating plant on Route 1A. The project provided a reserve industrial cooling pool which could be utilized by the alewives as a spawning area. Bull Brook had been used by alewives for many years as they traveled upstream to reach the spawning grounds. Although some alewives were initially observed using the fishway soon after its construction (Jerome et al., 1968), this run has been nonexistent in the 1990s.

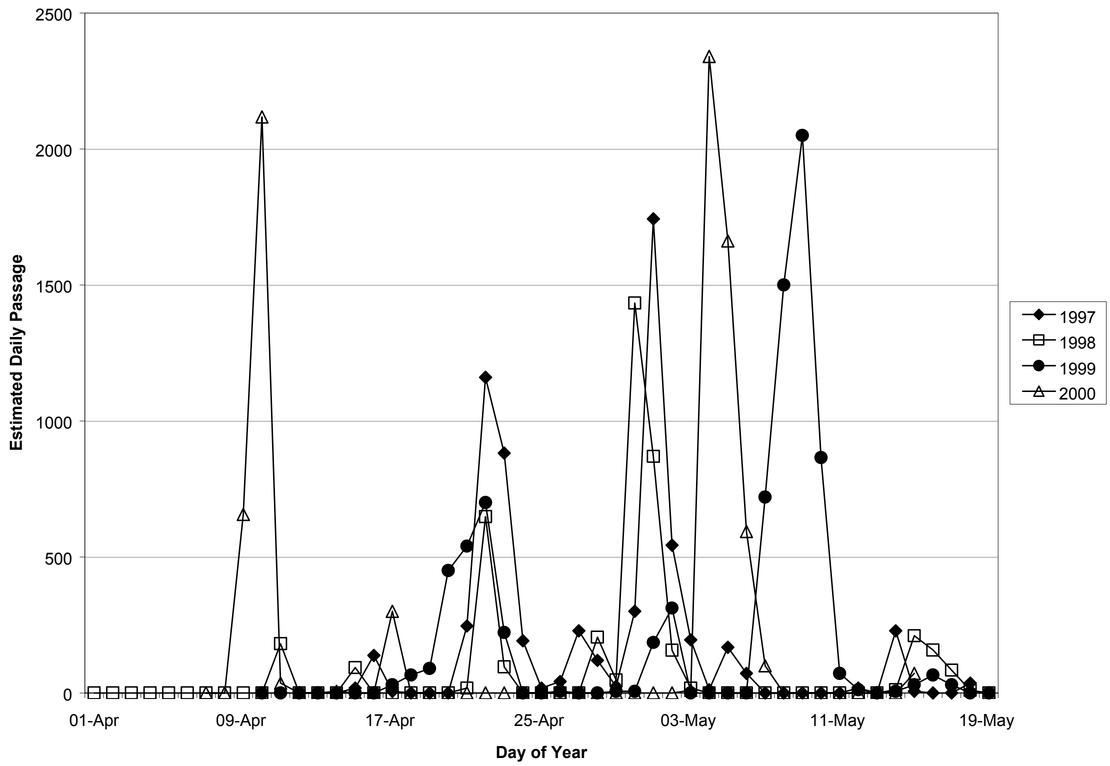
In the 1968 monograph it was reported that the spawning migration of alewives into the upper reaches of the Ipswich River was apparently blocked at the main dam in the center of Ipswich on Route 1A. Although a fishway existed at this site, few if any alewives were observed or reported passing through it. The report recommended that the possibility of reestablishing an alewife run in the upper reaches of the Ipswich River should be investigated. Since that time, emphasis has changed to restoring a blueback herring run instead of alewives. Although Wenham Lake was a historical spawning area for alewives, the Division of Marine Fisheries concluded that the number of potential spawning ponds favored by alewives was limited along the Ipswich. A new fishway was completed in 1997 after a habitat assessment carried out by Trout Unlimited and the Ipswich River Watershed Association under the guidance of DMF and the Riverways Program of the Department of Environmental Management indicated that there was potential spawning habitat for bluebacks in a number of locations above the first dam in the Ipswich.

4.24. Alewife Counts

There is little information on the numbers of alewives that ascended the Parker River annually before or during the period of large commercial landings which peaked in the 1950s. Local residents uniformly maintain that the numbers of alewives have declined dramatically in recent years. In 1973 and 1974, fish were counted as they ascended the fishways at dams #1, #5, and #6 as part of a study conducted by the University of Massachusetts (Beltz, 1975). The counting procedure consisted of estimating the total number of fish by counting for ten minutes every hour and multiplying the count by six. The 1973 total estimated count (Dam 1) was 38,102 and in 1974 the count was 34,638. Using the same method, counts coordinated by the Parker River Clean Water Association estimated that 6,397, 4,232, 7,965, 7,894 alewives passed up the Parker River to Pentucket Pond in 1997-2000.

In 1973, 61% of the fish passing dam #1 passed dam #5 and 39% made it past dam #6 into Pentucket Pond. In 1974, fractions were only 29% and 18% respectively.

Fig. 4.9. Alewife counts on the Parker River at the Central Street dam carried out by the Parker River Clean Water Association.



4.25. Blueback herring

Unlike alewives, there has been little documentation of blueback herring populations in the Parker River-Plum Island Sound region. Studies by the University of Massachusetts-Amherst in the 1970s indicated that bluebacks in the Parker River do not use the fishways, thus spawning is limited to such sites as the below the Woolen Mill on the Parker River in Byfield and below the dam at Glen Mills on the Mill River in Rowley. In 1997 large numbers of bluebacks were observed in the Little River for the first time in years. As discussed above, the rebuilding of the fishway around the Sylvania Dam in the center of Ipswich will hopefully allow access to more spawning sites. The Ipswich River Watershed Association conducted a volunteer count of bluebacks in 1999 and 2000 and recorded seeing 53 and 35 fish respectively. A volunteer count is being organized for the 2001 run. A fishway constructed at the Glen Mills dam would open up several more miles of potential spawning habitat to bluebacks. At the present time, this dam is a barrier to further upstream migration .

4.3. Striped Bass

The striped bass has been an important commercial and recreational fish species in the Parker River-Plum Island Sound area for over a century. Large numbers of stripers migrating along the coast from major spawning areas in Mid Atlantic estuaries appear in the spring and remain until fall. Fishermen congregate during the season to fish from shore and from boats in the estuary and in the adjacent waters of Ipswich Bay.

Jerome et al., (1968) summarized the history of commercial striped bass fishing in the Parker River through the mid 1960s. Bass weighing as much as 75 pounds were reported seined in the area and sold in Boston for one cent per pound in the spring of 1866 and 1867. Large numbers of striped bass wintering in the Parker River and weighing from one to 12 pounds were taken in November, December and January by bow netting. In 1874, one to twelve pound fish caught this way were sold in Boston for \$20.00 a barrel in 1874. In 1920 four fishermen netted between 200 and 300 pounds per tide. The total catch for the 1920-21 season was about three tons.

Striped bass were particularly important to local residents during the Great Depression. Legislation passed in 1915 had made bow netting for striped bass illegal, however in 1931, the towns of Rowley, Newbury, and Georgetown were given permission to allow unemployed persons to use this method to catch the fish. A total of 4.4 tons of striped bass were caught by this method during a five week period in February and early March in 1931. During the winter of 1934-35, 26 tons of bass were caught with 40 bow net permits. Size composition of the catch was as follows: 7 to 8 pounds, 50 percent; 12 to 13 pounds, 30 percent; and 16 to 24 pounds, 20 percent. Large numbers of 6 to 10 inch bass were netted and released. In the 1936-37 season only six applications for fishing permits were received because many of the fishermen were employed on W.P.A. projects. Between five and six tons of stripers were caught and sold for an estimated \$3,850. Bow netting was again prohibited by state law in 1938.

In 1965, an estimated 1,000 pounds of striped bass, taken by anglers, were sold commercially for $250 at $0.25 per pound (Jerome et al., 1968).

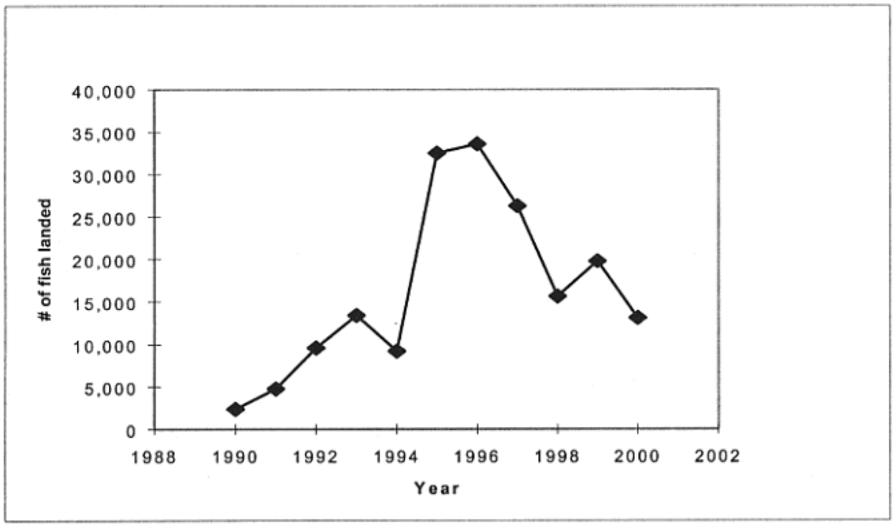
An interesting issue that still has not been resolved is whether striped bass have ever spawned in the Parker River. Bigelow and Schroeder (1953) cite a 1941 publication of Merriman in which he seined a few striped bass fry, ranging in size from 2 3/4 to 3 1/4 inches (7.1-8.5 cm long), from Parker River. The presence of striped bass fry in the river would indicate successful spawning activity by this species since they remain in their natal estuary for their first two years before beginning their seasonal migrations. No recent studies, such as those described earlier in this chapter and by the University of Massachusetts in the Parker River in the 1970s, have corroborated this result, so the issue still remains open.

In the 1980s, striped bass numbers were very low all along the east coast of the United States as a result of overfishing and pollution of their spawning areas. Strict management measures implemented in the 1980s drastically reduced both the commercial and recreational take. The resurgence of stripers in the early 1990s has been touted as a fisheries management success story.

In 1999 commercial fishing regulations included a minimum total length of 34 inches, a limited season of 40 days, required commercial fishing licenses and permits to sell the fish, and mandatory catch reports. The overall commercial quota for the east coast set by the Atlantic States Marine Fisheries Commission was 782,000lbs. Dealers purchasing and selling striped bass were required to have special authorization from the DMF in order to buy fish directly from fishermen. Dealers also had to file weekly and seasonal purchase reports. During 1999, the recreational fishing regulations included a minimum total length of 28 inches and a daily bag limit of one fish per person, no licensing or reporting was necessary.

The resurgence in striped bass numbers has led to a huge jump in the amount of fish caught since the 1980's (Fig. 4.10). The numbers of fish commercially landed in the Ipswich Bay to NH border area increased from 2,354 in 1990 to a high of 33,579 in 1996. Since 1996, Ipswich Bay numbers have decreased, with 13,087 caught in 2000. Across the state, there was a high in the amount of fish commercially caught in 1998, with a decrease shown in 1999.

Fig. 4.10. Commercial Striped Bass Landings from Statistical Area #1 (Ipswich Bay to NH border). Massachusetts Division of Marine Fisheries. Courtesy of David C. McCarron, Fisheries Economist, Massachusetts Division of Marine Fisheries Annisquam River Marine Fisheries Station



4.4 Smelt

Thomas Gage (1840) gives a feeling for the historical abundance of smelt in the region. "Mill River, which forms the dividing line, (in part) between this parish and Newbury, abounds with small fish of various kinds. Many thousand score of smelts are here taken and sold in Boston market yearly."

Smelt, *Osmerus mordax*, spend most of their lives in salt water, running up into fresh water to spawn. Five spawning sites were used by smelt in the study area during the period 1965 through 1967: at the Woolen Mill on Parker River, Newbury; Cart Creek, Newbury; Glen Mills on Mill River, Rowley; Rowley Town Brook, Rowley; and Egypt River, Ipswich. During this period, the bulk of the smelt ran during the month of April when the water temperatures were in the 40's (°F). In 1967, spawning runs occurred at all five sites. Research by the University of Massachusetts-Amherst in the 1970s documented only the first three of those spawning sites (Clayton, 1976).

Winter smelt fisheries formerly existed at five principal locations within the estuary: near Town Wharf on the Ipswich River, Ipswich; Rowley River, Rowley; Wood Island, Mill River, Rowley; and at South Shore and Thurlow's Bridge, Parker River, Newbury. The fishery commenced at the first safe ice and continued for indefinite periods depending on ice conditions controlled by winter thawing and tidal action. Usually smelt houses or screens were used to give protection from the wind and cold. The bulk of the fishing occurred at night.

attributes the decline in Parker River smelt to algal growth in their spawning areas (B. Chase, pers. comm.).

4.5. White Perch

The white perch is a common species in the low salinity, upper part of the estuary. Fishing is centered around Lee's Bridge in Little River and at Thurlow's Bridge in Parker River, Newbury since these sites are easily accessible by road. Traditionally, in the spring at apple blossom time, scores of fishermen with long cane poles would take this fish in considerable quantities although it can be caught from spring to fall (Jerome et al. 1968).

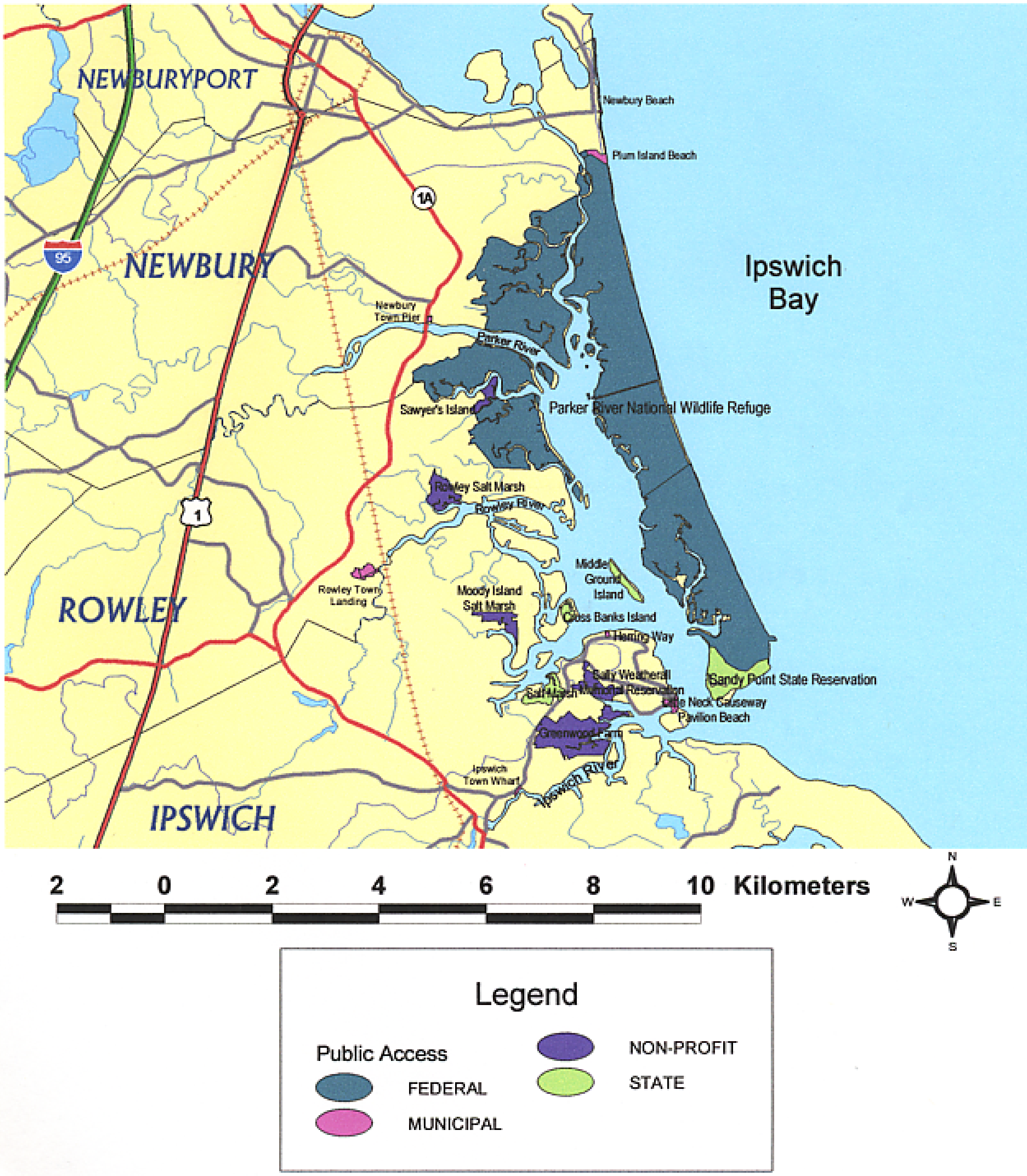
Bigelow and Schroeder (1953) state the white perch occasionally weigh two pounds or a little more, with the average being one pound or less. In the tidal creeks of the study area, white perch weighing two pounds are often taken. In 1966, seven white perch weighing 16 3/4 pounds were included in a catch taken by a single individual. At present, there are no size or harvest restrictions for this species.

Jerome et al. (1968) reported that during 1965, many anglers fished for white perch. In the 1990s, anglers were also observed fishing for white perch on the Parker River, but the general consensus was that the fishery was not as productive as in the past.

4.6. Boat launching ramps

The finfish species described above, such as white perch, winter flounder, and striped bass, have made the Parker River-Plum Island Sound Estuary a center for the sport fishing industry. Although much of this is carried out from shore, the presence of boat launching ramps provides the public with enhanced recreational opportunities.

Fig. 4.11. Public Access Sites (based on CZM map)



Note: Some town landing sites may be restricted to residents only, please check with local officials.

In 2000, there were four paved boat launching ramps in the study area, two of which were located on the Ipswich River, Ipswich. One is owned by the Ipswich Bay Yacht Club (formerly the Ipswich Outboard Club), and its use is restricted to members of the club. The second ramp**,** located at Town Wharf, is a public facility. A third launching ramp, is the town landing for Rowley and is located off Warehouse Lane on the Rowley River. Newbury's town landing is located on the Parker River at Route 1A and is heavily used by clammers for access to the Sound. There are a number of unpaved landings, including one on the Eagle Hill River in Ipswich, Bachelder Landing on the Rowley River in Rowley, and the lower landing off Cottage Road in Newbury (to the Parker River). Jerome et al. compiled daily use figures for the launching facility of the Ipswich Bay Yacht Club in 1965 (Table 4.17).

Table 4.17. Boat launchings at the Ipswich Bay Yacht Club in 1965. This ramp was used for approximately 26 weeks, from May through October.

Average number of boats launched per week (Monday thru Friday)	*15*
Average number of boats launched on weekends (Saturday and Sunday)	*50*
Average number of people per boat	3
Percentage of boats used for fishing	10
Launching fee per boat	$1.25
Total number of launchings (fishing)	169
Total revenue from launching fees (fishing)	$211.25
Total number of fishermen	507

In addition to the facilities for launching motor boats, a number of canoe access points have been developed in the estuary. These include put in places on the Ipswich River downstream from the Sylvania Dam, on the Mill River at Route 1 in Newbury, and on the Parker River off Middle Road near Thurlow's Bridge and at Newbury's lower landing. During 1965 and 1993/4, no party or charter boats operated out of the study area. Depending on the tides, boats from the Merrimack River occasionally take excursions into Plum Island Sound.

4.7. Summary

Historically, the finfisheries of the Parker River-Plum Island Sound area were of major economic importance. The commercial fisheries declined by the early 1900's and no longer make substantial contributions to the economy of the area. Recreational fishing, although fluctuating greatly over the years depending on the abundance of popular fish species is still a popular activity in the Sound. Striped bass are now a particular favorite species, as they have largely recovered from past overfishing. Mackerel, flounder, white perch, and Atlantic cod still are sought after by anglers in the Sound and off Plum Island beaches. Unfortunately smelt have declined to the point where the traditional Parker River winter recreational fishery for this species no longer exists.

From an ecological perspective, the estuary still provides spawning, nursery and feeding areas for many species of finfish. Abundant forage species, including the mummichog, silversides, and sand shrimp inhabit the shoal areas and marsh creeks. These areas are also used by winter flounder as a nursery habitat and seasonally by schools of young predatory striped bass and bluefish.

Anadromous species, including smelt, alewife and blueback herring, spawn in the headwater streams and spend one or more phases of their life cycle in the estuarine environment. The repair and maintenance of existing fishways, the physical improvement of certain spawning areas, and the construction of new facilities are needed to improve and insure the future of the anadromous fish populations (alewife, blueback and smelt) within the study area.